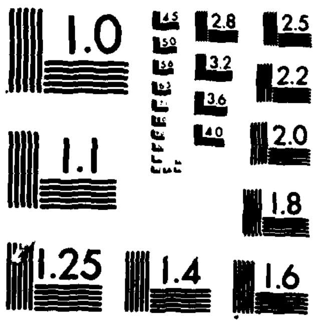
AD-A137 314 PINK WASTEWATER TREATMENT COSTS FOR A GRANULAR CARBON SYSTEM OPERATING AT..(U) CICCONE (V J) AND ASSOCIATES INC WOODBRIDGE VA V J CICCONE AUG 83 1/1

UNCLASSIFIED DRXTH-TE-CR-83248 DAAK70-82-M-0308 F/G 13/2 NL

END
DATE
FILMED
3-84
DTIC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A

5

AD A 137314

PINK WASTEWATER TREATMENT COSTS
FOR A GRANULAR CARBON SYSTEM OPERATING
AT FLOW RATES AT OR BELOW
DESIGN CAPACITY

CONTRACT NO. DAAK70-82-M-0308
(TASK NO. II)

VJA
V. J. CICCONE & ASSOCIATES,

DRXTH-TE-CR-83248

PINK WASTEWATER TREATMENT COSTS FOR A GRANULAR CARBON SYSTEM OPERATING AT FLOW RATES AT OR BELOW DESIGN CAPACITY

CONTRACT NO. DAAK70-82-M-0308
(TASK NO. II)

BY
V. J. CICCONE & ASSOCIATES, INC.
14045 JEFFERSON DAVIS HIGHWAY
WOODBRIDGE, VA 22191

AUGUST 1983

PREPARED FOR

U.S. ARMY TOXIC AND HAZARDOUS MATERIALS AGENCY
ABERDEEN PROVING GROUND, MD 21010

and

U.S. ARMY MOBILITY EQUIPMENT RESEARCH AND DEVELOPMENT COMMAND
FORT BELVOIR, VA 22060

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER DRXTH-TE-CR-83248	2. GOVT ACCESSION NO. AD-A137314	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Present Value-Unit Cost Estimates for Munitions Manufacturing Pink Wastewater Granular Carbon Treatment Systems Operating Intermittently and/or at Flow Rates Below Design Capacity		5. TYPE OF REPORT & PERIOD COVERED Final Report Jul 1983 - Aug 1983
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Vincent J. Ciccone, PhD, PE		8. CONTRACT OR GRANT NUMBER(s) DAAK70-82-M-0308
9. PERFORMING ORGANIZATION NAME AND ADDRESS V. J. Ciccone & Associates, Inc. 14045 Jefferson Davis Highway, Suite 5 Woodbridge, VA 22191		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 62720A,1L162720D048, EW, W-47
11. CONTROLLING OFFICE NAME AND ADDRESS U. S. Army Toxic & Hazardous Materials Agency Aberdeen Proving Ground, MD 21010		12. REPORT DATE August 1983
		13. NUMBER OF PAGES
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office) U.S. Army Mobility Equipment Research and Development Command Fort Belvoir, VA 22060		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for Public Release; Distribution Unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

This project was accomplished as part of the U.S. Army's Environmental Quality R&D Project D048. The objective of this project is exploratory development.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Present Value Analysis	Carbon Adsorption	Pink Wastewater
Present Value-Unit Cost	Pink Water	Cost Impact of Lower than Design Flow Rates
Least-Cost Operating Mode	TNT/RDX Wastes	
Present Value Economic Model	Activated Carbon	
Cost Functions	Carbon Columns	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The Present Value-Unit Cost (PVUC) methodology was applied to a hypothetical pink water treatment plant utilizing granular carbon adsorption and no regeneration of the spent carbon. The study analyzed the cost implications for a system design of 100,000 gallons per day (GPD) operating at its rated capacity after reduced flow values of the wastewaters are collected and stored versus the daily operation of the plant regardless of the influent flow rates.
Examined and qualified in Present-Value dollars was the effect of dedicated versus part-time labor for operation of the carbon plant. The differences were

(continued)

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered) then translated into potential annual savings and shown as a function of the daily input flows to the system.

DISCLAIMER

The views, opinions, and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy, or decision unless so designated by other documentation.

The use of trade names in this report does not constitute an official endorsement or approval of the use of such commercial products. This report may not be cited for purposes of advertisement.

EXECUTIVE SUMMARY

This report presents the results of a cost comparison study that may be applied to a pink water treatment plant utilizing granular carbon adsorption over a range of daily flow rates. The investigation examined a system designed for 100,000 gallons per day which is operated on a daily basis regardless of influent flow rates (10 to 70 thousand gallons per day) with dedicated labor (i.e., full-time operating personnel) versus operation at rated capacity after the reduced influent flows were collected and stored. In the latter, operational personnel were considered to be retained on a part-time basis (i.e., chargeable to plant operations only for those days the plant is actually operated). The two cases described above are identified respectively as "Daily" and "Intermittent" operational modes.

The Present Value-Unit Cost (PVUC) for each mode was calculated and compared. A significant difference, i.e., 44 percent greater cost per thousand gallons of pink water treated, was shown for the 10,000 gallon per day influent flow rate operated on a daily basis when compared to the intermittent mode. The difference became smaller as the daily influent flow rates increased with the rate of change being relatively moderate beyond 50,000 gallons per day. At the 90,000 gallons per day influent rate, the cost is 1.06 times greater than when the plant is operated in the intermittent mode. The analysis shows that operation of a 100,000 gallon per day granular carbon pink water treatment plant receiving less than design capacity daily influent flows, is more cost effective when operated on an "intermittent" basis rather than "daily" treatment of the influent flows.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1.0 INTRODUCTION

1.1 BACKGROUND

1.1.1 Since the Department of Defense (DOD) is responsible for a number of operations involving the manufacture and loading of explosives and/or propellants, it has been increasingly active not only in the modernization of munition production and loading plants, but also in programs to abate pollution of the environment which might occur from these operations. In keeping with this philosophy, extensive research efforts have been made by the DOD, the Army and the individual major commands, specifically U.S. Army Development and Readiness Command (DARCOM) through U.S. Army Toxic and Hazardous Materials Agency (USATHAMA), to seek out the most promising advanced wastewater treatment technologies and system designs to control pink wastewater discharges generated from such ammunition manufacturing and loading plants.

1.1.2 Included in the on-going Army research have been studies to identify those TNT (pink wastewater) treatment alternatives with the least-cost concentration or destruction processes capable of treating relatively large quantities of such wastewaters with relatively low or no concentrations of nitrobody pollutants observed in the effluents. Studies conducted by various sources, both within the military and under contract,[2,3,4] have identified several feasible technologies that, in terms of present value costs, form a preferable least-cost ordering table. A recent study conducted by V. J. Ciccone & Associates, Inc., (VJCA) under Contract No. DAAK70-80-C-0101 and reported in February 1982, estimated treatment unit costs in present value terms on a "systems" basis in which seven major pink water treatment technologies were evaluated. These costs were the outcome of economic evaluations of various state-of-the art processes, each representing a feasible alternative technology for the treatment of the pink wastewater. In the VJCA evaluation, literature searches were conducted, capital and operating costs were obtained from published and unpublished sources and, after appropriate adjustments to the assembled data to reflect basic vear dollar values, the data were converted to functions suitable for use in a VJCA-designed computer model. Computer simulations were conducted using the VJCA computer model to arrive at "Present Value-Unit Costs" (PVUC) for the seven pink wastewater pollution treatment alternative technologies. The PVUC (and subsequently the Uniform Annual Costs) for each technology studied were calculated and reported for plant designs with capacity flows of 10^5 and 10^6 gallons per day (GPD). By calculating the PVUC's for six 5-year horizons over the full 30-year life of the plants, a ranking of the different processes was made with the first-ranked technology representing the preferred (least-cost) process which met the pollution control standards previously set.

1.1.3 The results of the VJCA computer simulations contained in its February 1982 report showed the following relative ranking of alternatives:

a. Granular carbon with thermal regeneration
b. Granular carbon with no regeneration
c. Surfactant complexing
d. Powered carbon with atomized suspension technique (AST) regeneration
e. Ultraviolet-ozone
f. Liquid/liquid extraction
g. Ultrafiltration

1.1.4 After reviewing the results of the VJCA present value estimates and the relative ranking of the alternative pink wastewater treatment technologies arrived at by the VJCA analysis, Army representatives requested that cost implications of operating a designed full-scale 10^5 GPD plant at intermittent flow levels and/or periods be determined utilizing the capital and operating cost functions derived by VJCA in its pink wastewater treatment economic evaluation study conducted under Contract No. DAAK70-80-C-0101.

1.1.5 Intermittent operations imply that plants designed for a full mobilization flow of, for example, 10^5 GPD would not be needed to treat much smaller daily flow rates, but are desirable to have as instantly available capacity should the daily flow requirements escalate either suddenly or over a short period of time due to a defense emergency or some other similar strategic need. In an intermittent operation mode, plants might be inoperative for periods of time and then re-started as the need arose.

1.2 OBJECTIVES

1.2.1 The objectives of this study were to:

a. Utilizing capital cost functions previously derived by VJCA, identify operation and maintenance cost functions for intermittent operations.
b. Through literature searches, plant visits and technical analyses, obtain costs factors associated with intermittent plant operations.
c. Using the VJCA PVUC computer model, calculate the PVUC's for operations at daily influent flow rates below design flow capacities for a given pink wastewater treatment technology, namely, *granular carbon without carbon regeneration.*
d. Compare intermittent operating costs with reduced daily flow rates below the maximum plant design flow capacity.

1.3 TECHNICAL APPROACH

1.3.1 The PVUC methodology[1] incorporated by VJCA into a computerized mathematical model and used in this study, evaluates the costs in present value terms (capital costs and annual recurring operating and maintenance costs, after adjusting for inflation and rates of return over the economic life of the project-plant) of operating a granular carbon (without regeneration) pink water treatment plant at various daily flow levels which are below the plant design daily flow capacity. The calculated results may then be presented in tabulated and graphical formats. These data are further analyzed using mathematical procedures to identify that point on the PVUC-Daily Flow Rate curve which represents the daily flow rate below the maximum design capacity which would incur the least additional costs. This represents the most efficient lower-than-capacity daily flow level for that given plant design and technology and compares these with costs calculated for the periods of intermittent operations producing the most cost-efficient results.

1.3.2 After assessing the results of the lower daily flow rate analysis, recommendations are made for adjustments to the plant flow design to accommodate it to the recommended least-cost lower daily flow rate or to the intermittent schedule with the lowest costs.

2.0 INVESTIGATION

2.1 LITERATURE SEARCH

2.1.1 A literature search was conducted to identify the procedures, problems, costs, and feasibility of intermittent operations at similarly designed plants treating pink or other wastewaters. In addition, data and operating procedures were obtained from on-line pink wastewater treatment plants at the Milan Army Plant in an effort to assess intermittent operating modes and average daily flow rates both into and out of the plant. Patterns and recurring cycles were identified and examined for cause and regularity and assessments made as to applicability to other similarly designed plants. The practicality, costs and other factors associated with intermittent operations, including start-up and shut-down procedures and costs, were assessed from available literature and accumulated data.

2.2 SITE VISITS

2.2.1 Site visits were made and conferences held at the following installations:

a. Large Caliber Weapons System Laboratory, Dover, NJ
b. Milan Army Army Ammunition Plant, Milan, TN
c. U.S. Army Toxic and Hazardous Materials Agency, APG, MD.

2.2.2 During these site visits, operating personnel as well as managers involved in pink wastewater treatment processes or research activities were interviewed. In addition, relevant data and references were obtained where available. Finally, site visits were supplemented by either telephone discussions or by written correspondence in order to clarify or expand on the information and data previously obtained.

2.3 THE PVUC COMPUTER MODEL

2.3.1 The VJCA PVUC computer model is specifically designed to evaluate wastewater treatment facilities. It evolved from earlier versions by Ciccone[1] and Morgan.[2] As was the case in Morgan, this program is in an interactive format in Micropolis Extended BASIC (Micro-BASIC) and is run on a Vector Graphics Micronet II system. A typical output is shown in Computer Output 2.3.1.

2.3.2 The program is subdivided into five programs identified as PVUC-PART1, PVUC-PART2, PVUC-PART3, PVUC-PART4, and PVUC-PART5, respectively. Briefly, these programs perform the following functions.

2.3.2.1 PVUC-PART1: Through an interactive mode, PART1 gathers necessary preliminaries, such as operator name, date, titles of both systems associated with the present analysis, interest rate, inflation rate, and projected operational days per year. The title page to the output then is printed and the program automatically chains to PART2.

2.3.2.2 PVUC-PART2: This part of the program is used to introduce the actual design of any two alternative wastewater treatment systems under study. There is an option at the beginning of PART2 for the user to obtain a printout, if desired, of the catalog of units available in memory from which the two alternative treatment systems are to be compared. The user begins by designing the first system. An option exists either to call units from the PVUC equipment catalog by specific number and use the values for each unit stored in memory or to call a unit and modify values (costs, sizes, numbers, etc.) according to the needs of the treatment system being designed. The user may alternate between the above options during the design process.

Once the design for a treatment system is complete, it may be displayed or a hard copy printout may be prepared for examination and revision. Once the first treatment system design is satisfactory, the program moves directly into the design of the second treatment system. The procedures and options for designing the second system are identical to those for the first system. On completion of the treatment system design phase, the user may chain to either PART3 or PART4. Once this option is taken, the chaining automatically occurs.

COMPUTER OUTPUT 2.3.1

SUMMARY OF PVUC ANALYSIS COMPARING

SYSTEM (A): CARBON: NO REGENERATION (0.652 LBS TNT/LB C)

WITH SYSTEM (B): CARBON: WITH REGEN (0.652 LBS TNT/LB C)

FOR FLOW RATE OF 10 000 GPD

BY

GEORGE A. GARRIGAN

JULY 15 1983

COMPUTER OUTPUT 2.3.1

TABLE 1. LISTING OF ALL COMPONENTS FOR PVUC STUDY.
BASELINE FOR ALL COSTS IS DECEMBER, 1980 UNLESS
INDICATED OTHERWISE IN THE BODY OF TABLE. FLOW IS
10 ,000 GPD

ALTERNATIVE (A)
CARBON: NO REGENERATION (0.652 LBS TNT/LB C)

NAME OF UNIT UNDERWRITTEN BY:

CAT NO.	NOS. UNIT	UNIT CAP COST	UNIT O&M COST	CAPACTY (GAL)	UNIT GPD	LIF YRS
SUMP-STL OR MI						
9028	1	$ 6900	$ 0	20000	10000	30
PUMP-PRESS. SUMP						
9007	2	$ 1786	$ 3326	7.58	10000	30
EQUALIZATION/SEDIMENTATION TAN						
9018	1	$ 18777	$ 0	100000	10000	30
PUMP-PRESS. EQUALIZATION						
9006	2	$ 1047	$ 1737	2.66	10000	30
FILTER-PRESSURE-DE						
9015	2	$ 43865	$ 849	200	5000	30
CARBON COLUMN-GRANULAR						
9013	1	$ 151367	$ 71160	2000	10000	30
WASTE CARBON TNK-STL OR MI						
9014	3	$ 5511	$ 0	12000	100	30
VIRGIN CARBON STORAGE TANK						
9008	1	$ 7709	$ 0	24000	24000	30
PUMP-PRESS. BACKWASH-D.E.						
9004	1	$ 879	$ 4	1.89	1000	30
CONVEYOR SCREW						
9031	1	$ 4566	$ 1000	1	25	30
HOLDING TANK						
9023	1	$ 7612	$ 0	25000	10000	30

ALTERNATIVE (B)
CARBON: WITH REGEN. (0.652 LBS TNT/LB C)

NAME OF UNIT UNDERWRITTEN BY:

CAT NO.	NOS. UNIT	UNIT CAP COST	UNIT O&M COST	CAPACTY (GAL)	UNIT GPD	LIF YRS
SUMP-STL OR MI						
9028	1	$ 6900	$ 0	20000	10000	30
PUMP-PRESS. SUMP						
9007	2	$ 1786	$ 3326	7.58	10000	30
EQUALIZATION/SEDIMENTATION TAN						
9018	1	$ 18777	$ 0	100000	10000	30
PUMP-PRESS. EQUALIZATION						
9006	2	$ 1047	$ 1737	2.66	10000	30
FILTER-PRESSURE-DE						
9015	2	$ 43865	$ 849	200	5000	30
CARBON COLUMN WITH THERMAL REG						
9019	1	$ 151367	$ 5929	2000	10000	30
WASTE CARBON TNK-STL OR MI						
9014	3	$ 5511	$ 0	12000	100	30
VIRGIN CARBON STORAGE TANK						
9008	1	$ 7709	$ 0	24000	24000	30
PUMP-PRESS. BACKWASH-D.E.						
9004	1	$ 879	$ 4	1.89	1000	30
CONVEYOR SCREW						
9031	1	$ 4566	$ 1000	1	25	30
CARBON DE-FINE TANK						
9040	1	$ 45947	$ 1000	2500	2500	30

--CONTINUED

```
!HOLDING TANK
! 9023  1  $ 7612  $ 0       25000  10000   30
!
!CARBON REGEN FURNACE
! 9011  1  $ 528487$ 2844    1      30      30
!
```

***** NOTE: ALL VALUES ROUNDED TO NEAREST INTEGER *****

****

STUDY CONDUCTED BY GEORGE A. GARRIGAN JULY 15 1983

TABLE 2. PRESENT VALUE UNIT COST ANALYSIS
COMPARING TREATMENT A (CARBON: NO REGENERATION (0.652 LBS TNT/LB C))
WITH TREATMENT B (CARBON: WITH REGEN. (0.652 LBS TNT/LB C)).
SYSTEM LIFESPAN TO BE 30 YEARS WITH 350 OP. DAYS PER YEAR.
ANALYSES ARE OVER FIVE YEAR SPANS (OR 'HORIZONS').

TOTAL CAPITAL COSTS FOR ALTERNATIVE A = $ 307750 AND FOR ALTERNATIVE B = $ 869657;
RATIO OF CAPITAL COSTS OF B TO CAPITAL COSTS OF A = 2.82; DISCOUNT RATE = .02;
FLOW RATIO OF A TO B ('ALPHA') = 1.0000
DAILY FLOW IN SYSTEM A = 10 000 GALLONS: SYSTEM B = 10 000 GALLONS.

VALUES USED FOR DECISION PROCESS	TOTAL YR 1 TO 5	TOTAL YR 1 TO 10	TOTAL YR 1 TO 15	TOTAL YR 1 TO 20	TOTAL YR 1 TO 25	TOTAL YR 1 TO 30
TOT. OP. COSTS FOR ALTERN. A $	395000	754000	1079000	1373000	1639000	1881000
TOT. OP. COSTS FOR ALTERN. B $	106000	203000	290000	369000	441000	506000
DISCOUNT SALVAGE VALUE FOR A $	232000	168000	114000	69000	31000	0
DISCOUNT SALVAGE VALUE FOR B $	656000	475000	323000	195000	88000	0
SLVG PER DISCNT CAP. (THETA-A)	.68362	.44864	.27603	.15096	.06192	< 10E-5
SLVG PER DISCNT CAP. (THETA-B)	1.93182	1.26781	.78003	.42660	.17498	< 10E-5
TOT. FLOW (MGAL) FOR ALTERN A	17	35	52	70	87	105
TOT. FLOW (MGAL) FOR ALTERN B	17	35	52	70	87	105
RSUM FOR ALTERNATIVE A	3.91019	13.88386	29.34941	49.78913	74.73410	????????
RSUM FOR ALTERNATIVE B	1.05238	3.73668	7.89906	13.40019	20.11385	27.9257
THE DISCRIMINANT IS	2.2801	9.1404	20.1284	34.8387	52.9074	74.007
PVUC ($/KGAL PROCESSED): A $	26.93	25.54	24.24	23.03	21.90	21.9
PVUC ($/KGAL PROCESSED): B $	18.27	17.05	15.94	14.91	13.97	13.9
UNIFORM ANNUAL COST (A) $	28.57	28.43	28.29	28.16	28.04	27.9
UNIFORM ANNUAL COST (B) $	19.38	18.99	18.61	18.24	17.89	17.5

STUDY CONDUCTED BY GEORGE A. GARRIGAN JULY 15 1983

2.3.2.3 PVUC-PART3: If PART3 is elected, the Micronet will automatically provide a printout of the complete design specified by the operator of both wastewater treatment systems to be compared. The printout will include a listing of all pertinent data for each treatment unit as determined previously by the operator. If the hard copy is determined by the computer to be too extensive for one page, a special pagination mode will be automatically activated, and printout will be delayed at the end of each page to allow for readjustments of the paper positioning. At the termination of printing, there is an automatic chaining to PART4.

2.3.2.4 PVUC-PART4: Upon entering PART4, the program will designate the flow (GPD) for both alternative treatment systems. The operator chooses which flow is to be designated by selecting the appropriate version of PVUC program entered into the computer. Either program permits the options for a hard copy printout of calculations pertaining to the analysis or a direct advancement to a graphical printout, PART5. Given either option, all pertinent calculations are accomplished at this point before execution of the option. Calculated values are stored in an array with six columns (one for each of six 5-year horizons) and twenty horizontal lines (one for each variable type under study). If the printout of the result of the calculations is requested, it is executed in tabular format, on one page, with the option for the operator to interject comments about the study which are felt to be pertinent. Once the table is complete, there is an automatic chain to PART5.

2.3.2.5 PVUC-PART5: PART5 automatically adjusts the size of the graph to be produced to fit the maximum space selected, and then prints the Discriminant (i.e., the normalized difference between the PVUC for "A" and PVUC for "B") curve before the printout of the PVUC curves for each alternative wastewater treatment system. Both curves are printed on one graph. The vertical heights of each graph, with appropriate axis labels and captions, are set to display attractively on standard sized (8 1/2 inch by 11 inch) paper.

2.4 COST FUNCTION ADJUSTMENTS

2.4.1 Using the VJCA PVUC computer model as a base (Reference 3), adjustments were made in the model subparts to accommodate an analysis of the lower-than-maximum design capacity flows for a 10^5 GPD granular carbon pink water treatment plant without carbon regeneration. (See paragraph 2.6).

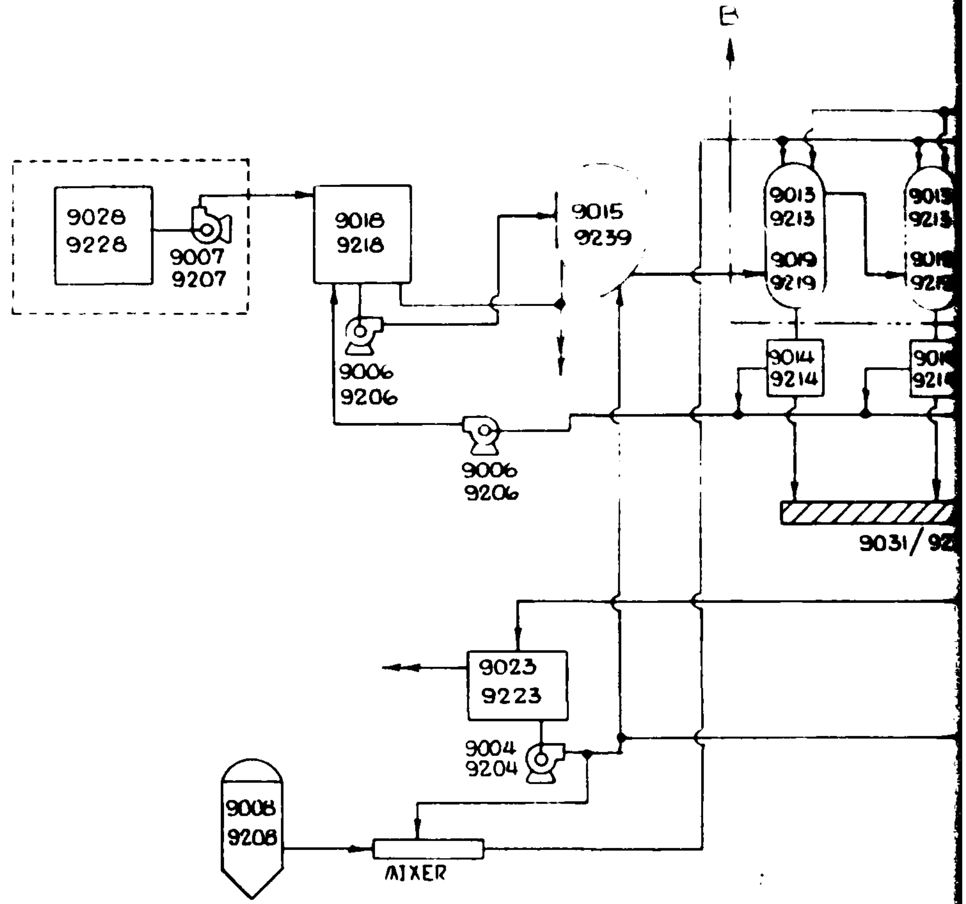
2.4.2 An important feature of the VJCA PVUC Computer model is its adaptability to changing conditions (either economic or technical engineering) and its ability to make instantaneous comparisons with other protocols or flow levels. One major element of the model is the cost functions for various plant designs, capacity flows, equipment prices as well as other factors which affect costs as the size and design of the plant changes. In this study, the cost functions used in Reference 3, were reviewed and, where necessary, they were adjusted to reflect the physical operating conditions being analyzed.

2.5 BASE YEAR DOLLAR VALUES

2.5.1 In a previous PVUC computer study conducted by VJCA,[3] capital and operating cost data were gathered from various sources, most of which were stated in different time frames. In that study, VJCA adjusted these data to a common base year, and all results reflected prices as they existed in December 1980. Since this analysis is so closely related to the original PVUC evaluation, and since comparisons with the PVUC's calculated for pink wastewater treatment processes in the original study will be made, it was decided not to adjust cost data beyond the original base year of December 1980. Therefore, costs reported in this study for the various daily flow rates are in December 1980 dollar values.

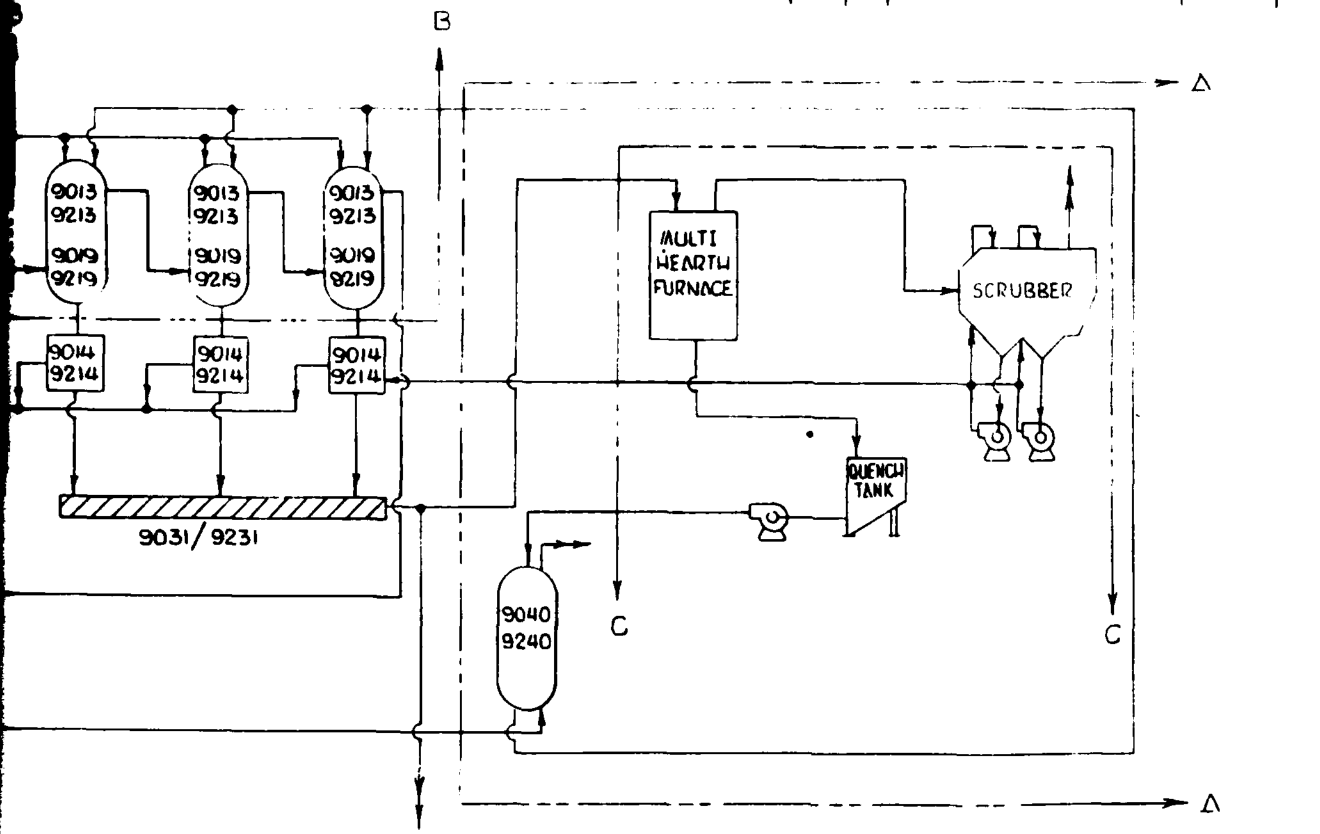
2.6 OPERATIONAL SCENARIOS STUDIED

2.6.1 Based upon guidance by the MERADCOM and USATHAMA project officers and the fact that, presently, Army ammunition plants are not regenerating spent carbon, the scenarios studied here concentrated on carbon adsorption with no regeneration as the treatment alternative.



PVUC CAT. NUMBER		NOMENCLATURE
10^6GPD	10^6GPD	
9004	9204	PUMP- BACKWASH FILTER
9006	9206	PUMP- PRESSURE EQUALIZATION
9007	9207	PUMP- PRESSURE SUMP
9008	9208	VIRGIN CARBON STORAGE TNK
9011	9211	CARBON REGENERATION SYSTEM
9013	9213	CARBON COLUMN - GRANULAR (W/O REGEN)
9014	9214	WASTE CARBON TANK
9015	9239	FILTER PRESSURE - DE (OR MIX MEDIA)
9018	9218	EQUALIZATION SEDIMENTATION TNK.
9019	9219	CARBON COL. WITH THERMAL REGEN.
9023	9223	HOLDING TANK
9028	9228	SUMP - STL OR MI
9031	9231	CONVEYOR, SCREW
9040	9240	CARBON DE-FINE TANK

REVISIONS				
ZONE	REV	DESCRIPTION	DATE	APPROVED



NOTES:

1 - SECTION A-A = REGENERATION SYSTEM W/9040/9240

2 - SECTION B-B = 9013 9213 W/O REGENERATION

3 - SECTION C-C = REGENERATION SYSTEM 9011/9211

ION
TNK
STEM
R(W/O REGEN)
MEDIA)
ION TNK.
REGEN.

FIGURE 2.1 GRANULAR CARBON ADSORPTION

INTERPRET DRAWING IN ACCORD WITH DOD-STD-100

CONTRACT DAAK 70-80-C-0101

THIS DOCUMENT IS PROPRIETARY TO V.J. CICCONE & ASSOCIATES, INC., AND SHALL NOT BE REPRODUCED IN ANY FORM, NOR DISCLOSED TO OTHERS, EXCEPT WHERE OTHERWISE AUTHORIZED.

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
TOLERANCES: ANGLES ±
3 PLACE DECIMALS ±
2 PLACE DECIMALS ±

DRAWN SS 9-5-81
CHECKED
APPROVED
DATE

V. J. CICCONE & ASSOCIATES, INC.
ENGINEERING SERVICES

GRANULAR CARBON ADSORPTION

SIZE C | FSCM | DWG NO. FIGURE 2.1

SCALE | SHEET 1 OF 18

DWG. NO.
SH
REV

2 1

2

D

TABLE 2.1 DATA SHEET, GRANULAR

C

PVUC CAT. NUMBER	9004	9006	9007	9008	9011	9013	9014	9015	90
NOMENCLATURE	PUMP BKWH.	PUMP FILTER	PUMP SUMP	TANK V.CARBON	REGEN. SYSTEM	CARBON COLUMN	WASTE TANK	FILTER D.E.	TA EQ
DIMENSIONS	2 x 2	2 x 2	2 x 2	18.0D x 14.0'H	6.0' D	7.0'D - 16.0'H	15.0'D - 8.0'H	2.5'D x 5.0'H	9.0'
CAPACITY				20,000 (24,000 GAL)	6720 LBS/DY	308 CU.FT. CARBON	10,000 (12,000 GAL)		100. G
MATERIAL	M. I.	M. I.	M. I.	STEEL	M. I.	STEEL	STEEL	COATED M. I.	STL/
TYPE	CNTFGL.	CNTFGL.	CNTFGL.	VERT. CYL.	5-HEARTHS	GRANULAR	VERT. CYL.	VERT. CYL.	REC
ENERGY REQ.	2.5 Kwh.	4 Kwh.	4 Kwh.						
PRESSURE	45 PSI	65 PSI	25 PSI			25 PSI		45-55 PSI	
RATE	70 GPM	70 GPM	150 GPM		4 LBS./FT.²	70 GPM		70 GPM	
HYDR. LOAD					280 LBS/HR	1.8 GPM/FT²		2.5 GPM/FT²	
EFFECTIVE AREA					HEARTH AREA 70 FT.²	38.5 FT.²		28 FT²	
MEDIA VOLUME						9866 LBS./COLUMN		22 LBS/DY.	
BKW. PERIOD								5 MIN.	
BKW. RATE								70 GPM	
HYDRAULIC HP	1.9 HP	2.6 HP (2.66)	2.2 HP (7.58)						
DETN. TIME					30 MIN.	35 MIN.			24
EQUIP. QUANTITY	1	2	2	1	1	1 UNIT = 3 COLUMNS	3	2	1
OTHER DATA				2-CARBON COLUMN		WITHOUT REGEN.	1/CARBON COLUMN		

B

NOTE:
NUMBER IN PARENTHESIS IS VALUE
USED IN THE ECONOMIC PVUC MODEL

A

4 3

REVISIONS				
ZONE	REV	DESCRIPTION	DATE	APPROVED

D

GRANULAR CARBON ADSORPTION 10^5 GPD

9014	9015	9018	9019	9023	9028	9031	9040		
WASTE TANK	FILTER D.E.	TANK EQUAL.	CARBON COLUMN	TANK HOLDING	SUMP	CONVR. SCREW	TANK DE-FINE		
0'D-8.0'H	2.5'D x 5.0'H	9.0'x18.5'x8.0'	7.0'D x 16.0'H	19.0'D x 12.0'H	18.0'D x 12.0'H	9.0'D x 25.0'L	7.0'D x 16.0'H		
0,000 (2000 GAL)		100,000 GAL.	308 CU. FT.	25,000 GAL.	20,000 GAL.		3070 (2500)		
STEEL	COATED M.I.	STL/EXCAV.	STEEL	STEEL	STEEL	STEEL	STEEL		
RT. CYL.	VERT. CYL.	RECT.	GRANULAR	VERT. CYL.	VERT. CYL.	CYL.	VERT. CYL.		
						1.5 Kwh.	4 Kwh.		
	45-55 PSI		25 PSI						
	70 GPM		70 GPM			280 LBS/HR.	BKWH. WATER 200 GPM		
	2.5 GPM/FT²		1.8 GPM/FT²						
	28 FT²		38.5 FT²						
	22 LBS/DY.		9856 LBS./COLUMN						
	5 MIN.								
.	70 GPM								
		24 HRS.	35 MIN.		4.7 HRS.		15 MIN.		
3	2	1	1 UNIT = 3 COLUMNS.	1	1	1	1		
CARBON COLUMN			W/ REGEN. ONLY						

C

DWG. NO.

SH

REV

INTERPRET DRAWING IN ACCORD WITH DOD-STD-100

CONTRACT DAAK 70-80-C-0101

THIS DOCUMENT IS PROPRIETARY TO V.J. CICCONE & ASSOCIATES, INC., AND SHALL NOT BE REPRODUCED IN ANY FORM, NOR DISCLOSED TO OTHERS, EXCEPT WHERE OTHERWISE AUTHORIZED.

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES: ANGLES ±
3 PLACE DECIMALS ±.
2 PLACE DECIMALS ±.

DRAWN	S3	9-5-81
CHECKED		
APPROVED		
DATE		

V. J. CICCONE & ASSOCIATES, INC.
ENGINEERING SERVICES

GRANULAR CARBON ADSORPTION
10^5 G.P.D.

SIZE	FSCM	DWG NO.
C		TABLE 2.1

SCALE | SHEET 2 OF 18

A

2 1

2

2.6.2 Carbon Adsorption Plant Design: Of all the processes employed for the removal of organic materials from wastewater, activated carbon has the longest history and is the best developed method in use today. Therefore, the process is well documented throughout the industrial and municipal wastewater treatment literature. Activated carbon is also effective in removing some inorganics from wastewater, particularly for some contaminants, at the trace levels. The process proceeds by adsorption or the attraction and accumulation of one substance on the surface of another. The decision whether to regenerate and reuse granular carbon or to use granular carbon without regeneration is based upon cost incentive. During the study, a visit was made to the Milan Army Ammunition Plant, Milan, Tennessee, to observe the operation of a granular carbon treatment process without regeneration.

Figure 2.1 and Table 2.1 show; the design for the 10^5 GPD granular carbon plant without regeneration, the assumptions were that influents to the pink water treatment plant would be collected in a subsurface sump. Intermittently, contents of the sump are pumped to a one-day retention equalization tank. Constant flow from the equalization tank would be pumped to a diatomaceous earth filter and from there to a bank of three carbon columns in series (2 operating, 1 standby), each with a detention time of 35 minutes. As the adsorption capacity of the carbon in a column is exhausted the carbon would be discharged and held in carbon waste tanks, each with a capacity of one carbon column. The liquid discharge, always from the third column operating in series (accomplished by appropriate piping arrangement), would flow to a 25,000 gallon holding tank. If appropriate (i.e., the NPDES permit requirements are met) the liquid plant discharge could be released at this point and discharged as plant effluent. Some of the liquid waste could be used again at the diatomaceous earth filter units for backwash operations. Any excess liquid accumulating in the waste carbon tanks would likewise be returned to the equalization tank. The plant has the capability for virgin carbon storage of a minimum of two carbon column capacity. The virgin carbon for make-up purposes is fed, as needed, into the carbon columns through a pipe mixer with water pumped from the holding tank.

For the non-regenerative granular carbon treatment process considered here the spent, unregenerated carbon, used on a once-through basis, must be ultimately disposed of by some acceptable technique. In this study the disposal method considered was "open burning". The O&M cost function used for "carbon column-granular" includes the cost of this disposal method.

2.6.3 The assumptions made to define the scenario of operation studied are as follows:

a. Plant design capacity: 10^5 GPD

b. Daily influent flows: 10^4 - 10^5 GPD. Evaluated for PVUC at 10,000; 30,000; 50,000; 70,000; and 100,000 GPD

c. Plant operated in two modes:

Daily (i.e. regardless of the input flow).
Intermittently (i.e. only after the assumed 10^5 gallon influent storage capacity had been satisfied).

d. Labor for Plant Operation:

(Note: one operator per day was selected based upon the considered non-hazardous (i.e. explosive) conditions of the wastewater stream, the semi-automatic design of the plant and its similarity to carbon adsorption municipal plants of the same capacity. However, it is noted that at any one specific munitions plant, there may be a requirement to satisfy other safety rules such as the buddy system which would require at least two operators.)

For <u>daily</u> operation labor is <u>dedicated</u> (i.e. 8 hr/day; 5 days/week; 350 days/year)

Labor rate: $8.50/hour
Benefits: 20.4% retirement
5.6% other

For intermittent operation, the above factors are the same, except that labor is part-time, i.e., operator, is charged to the plant operation only for those days of actual operation at full day increments.

e. Granular carbon exchange rate: .652 lbs TNT/lb carbon.

f. All other costs such as power heating, chemicals, ventilation, maintenance etc., remain the same.

3.0 FINDINGS

3.1 Table 3.1 summarizes the calculated PVUC's for both daily and intermittent plant operation for the conditions assumed in paragraph 2.6.3.

3.2 Figure 3.1 is a plot of the calculated PVUC's as summarized in Table 3.1.

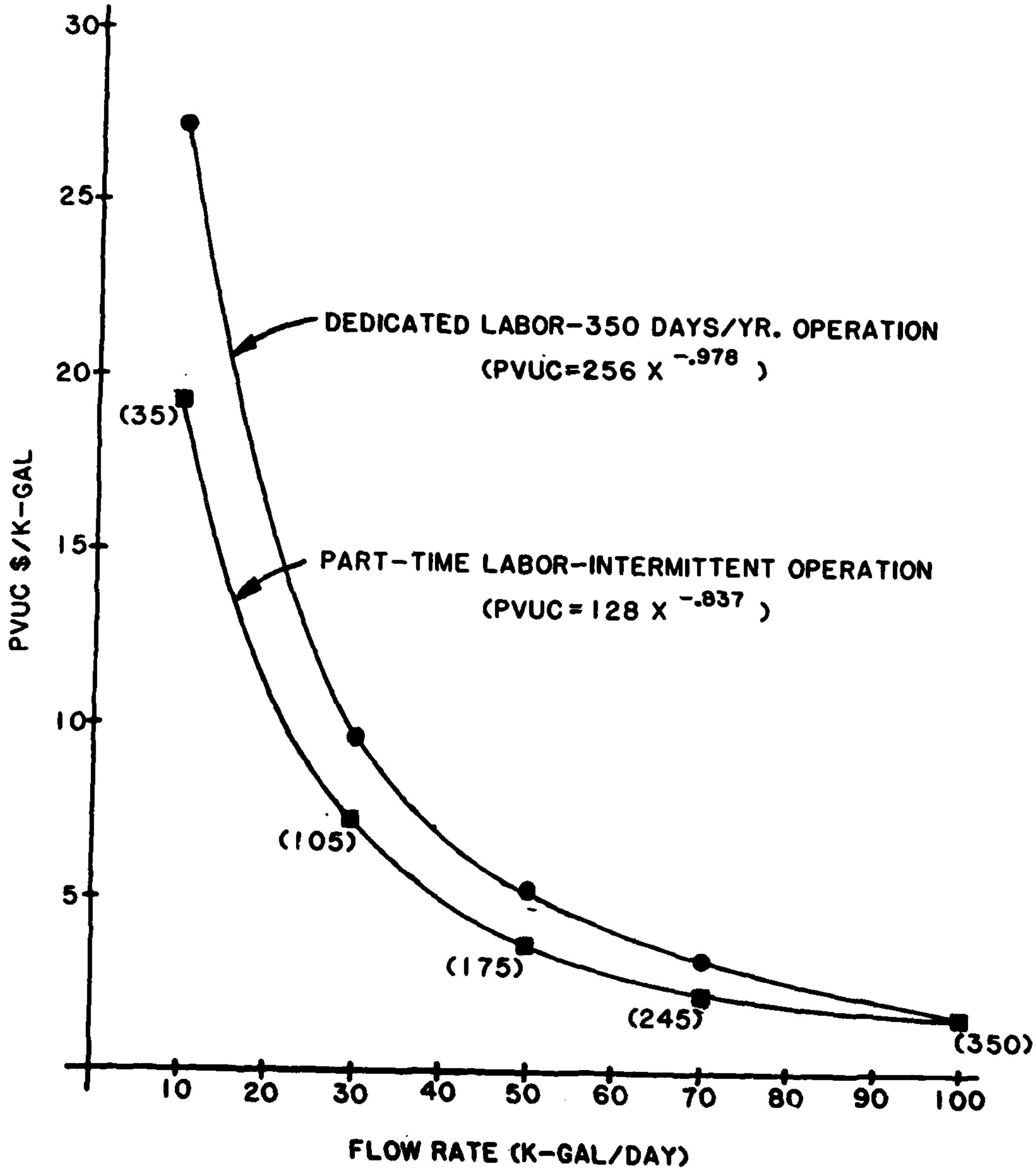
3.3 Table 3.2 shows the PVUC's calculated from the "fitted" curves for both modes of operation and flow rates from 10,000 to 100,000 GPD. Also shown is the ratio of the PVUC's for each mode of operation.

3.4 Table 3.3 presents projected annual savings in Present-Value dollars of the studied system when operated in an intermittent mode versus daily operation.

TABLE 3.1

SUMMARY OF CALCULATED PVUC'S
FOR 10^5 GPD (DESIGN)
CARBON ADSORPTION PLAN WITH NO REGENERATION

INFLUENT FLOW (KGAL/DAY)	10	30	50	70	100
DAILY OPERATION					
DAYS OF OPERATION/YEAR	350	350	350	350	350
CALCULATED PVUC ($/KGAL)	26.93	9.15	5.60	4.08	2.80
INTERMITTENT OPERATION					
DAYS OF OPERATION/YEAR	35	105	175	245	350
CALCULATED PVUC ($/KGAL)	19.22	7.16	4.75	3.72	2.80
DIFFERENCES					
SAVINGS (PV $/KGAL)	7.71	1.99	0.85	0.36	0.0



NOTE: NUMBERS IN PARENTHESIS REPRESENT DAYS OF OPERATION

FIGURE 3.1 CARBON COLUMNS-NO REGENERATION
PVUC-5 YR. HORIZON

TABLE 3.2

PVUC'S OF CARBON ADSORPTION NO REGENERATION
FOR BOTH MODES OF OPERATION
(CALCULATED FROM "FITTED" CURVES)

FLOW RATES (KGAL/DAY)	$/KGAL DAILY	INTERMITTENT	RATIO
10	26.94	18.70	1.44
20	13.68	10.47	1.31
30	9.20	7.46	1.23
40	6.95	5.86	1.18
50	5.58	4.86	1.15
60	4.67	4.18	1.12
70	4.02	3.67	1.09
80	3.53	3.28	1.07
90	3.14	2.98	1.06
100	2.83	2.72	1.04

TABLE 3.3

PROJECTED ANNUAL SAVINGS
(IN PRESENT-VALUE DOLLARS)
INTERMITTENT VERSUS DAILY OPERATION

DAILY FLOW RATE (KGAL/DAY)	ANNUAL VOLUME TREATED (MG)	CALCULATED PVUC SAVINGS ($/KGAL)	PROJECTED ANNUAL SAVINGS (PV$)
10	3.5	7.71	26,985
30	10.5	1.99	20,895
50	17.5	0.85	14,875
70	24.5	0.36	8,820
100	35.0	0.00	0

4.0 DISCUSSION

4.1 As mentioned in paragraph 2.6, the carbon adsorption with no regeneration treatment alternative was selected for study here, because this pink-water treatment technique is presently being selectively employed by the U.S. Army. The economic examination of a hypothetical case for the design and operation of such a plant is therefore not only appropriate, but timely. Consequently, two sets of PVUC calculations were conducted to determine the PVUC variations where the described granular carbon plant is operated on a "daily" versus an "intermittent" basis. "Daily" operation means that the system treats the influent flow everyday and that the system storage capacity of 10^5 gallons is not fully utilized until the daily flow rate is at the value. "Intermittent" operation means that daily influent flow quantities below the 10^5 value are stored in the system until storage capacity is reached, and then the plant is operated at capacity to treat the stored 10^5 gallons of pink water.

4.2 The assumptions presented in paragraph 2.6.3 were used to establish a reasonable scenario of operation for calculating the PVUC's. In this manner a relative comparison of anticipated unit costs could be made. The hourly labor rate of $8.50 was chosen as being consistent within the water/wastewater treatment industry, while 20.4% retirement, and 5.6% other benefits values were obtained from the OMB A-76 Circular which is used by DOD to make cost evaluations.

It is imporatant to note that in the daily operational mode, the plant operator (i.e. labor) is dedicated (meaning full-time employment) and is so charged against the plant operational costs. In the intermittent mode, the operator is considered part-time and charged against operations only for those days of actual plant operation. Additionally, labor is charged in full-day increments. This implies that this part-time operator is qualified to perform in more than one specialty (e.g. boiler plant operations, electrician, mechanic) and is utilized elsewhere within the ammunition plant complex when not actually operating the pink water carbon adsorption treatment system.

4.3 Table 3.1 which summarizes the PVUC computer model calculations for both modes of operation shows the range of the PVUC being $26.93/Kgal (for 10,000 GPD input flows) to $2.80/Kgal (for 100,000 GPD input flows) for the daily mode of operation, and $19.20/Kgal to $2.80/Kgal (for the same input flows) for intermittent plant operation. The calculated "differences" represents the value of dedicated versus part-time labor for each mode of operation. The range of potential savings is $7.71/Kgal (i.e. Present-Value dollars) for the 10,000 GPD input flow rate to zero for the 100,000 GPD flow rate. A significant difference is apparent as the flow rate is increased from 10,000 to 30,000 GPD with the rate of change being relatively moderate beyond 50,000 GPD.

4.4 Figure 3.1 shows the calculated PVUC values for both modes of operation as two plotted power functions with the "fitted" equations being $PVUC = 256X^{-.978}$ and $PVUC = 128X^{-.837}$ for the daily and intermittent modes respectively. These fitted curves were subsequently used to generate Table 3.2 which presents PVUC's for each mode of operation for input flows of 10,000-100,000 GPD in increments of 10,000. A review of this data shows that the ratio of unit costs for daily to intermittent operation varies from 1.44 at the 10,000 GPD flow to 1.06 for the 90,000 GPD value. This indicates that for this treatment alternative (i.e. granular carbon with no regeneration) a 10^5 GPD capacity plant that is operated daily when influent flow rates are at the 10,000 GPD value costs about 1.44 (or 44% greater) times greater to treat each 1,000 gallons then if it were operated on an intermittent basis with storage of the influent in-between operational days. At the 90,000 GPD influent rate the difference is only 1.06 times as great. A similar analysis may be made for each of the other flow categories.

4.5 When examined from an annual cost view, the calculated PVUC can provide an estimate of relative cost savings (in Present-Value dollars) projected when lower than capacity daily flow inputs are stored and treated on an intermittent rather than a daily mode of operation. Table 3.3 shows such projections. It must be noted here that these values reflect only those savings that might be expected when the labor contribution to the plants operational costs are modified from dedicated to a part-time situiation. In line with the assumptions made in paragraph 2.6, the potential contributions from other factors such as power, heating, etc... have not been evaluated.

4.6 The objective in this study was to demonstrate whether a cost impact was realized given the different modes of operation. The results obtained here should not necessarily be interpreted as specific to any one AAP, but rather as an approach to evaluating present and future plans regarding designs and actual modes of operation. If evaluations of specific plant operations are desired, further cost-function adjustments and refinements specific to that plant would be necessary.

5.0 CONCLUSIONS

5.1 The operational mode of granular carbon pink wastewater treatment systems can have a large impact on cost.

5.2 The magnitude of the cost impacts can be determined by the application of mathematical procedures, such as curve-fitting cost data sets generated by the PVUC model.

5.3 On the basis of the PVUC analyses, operation of a 10^5 GPD granular carbon pink water treatment plant without regeneration of spent carbon, receiving less than capacity daily influent flows, is more cost-effective when operated on an intermittent basis (i.e., storage of influent and subsequent periodic treatment) rather than daily treatment of the accepted influent flows.

5.4 Based upon inspection of the data and Figure 3.1, in general, serious cost penalties are not expected for daily flows above the 70 percent of capacity for a granular carbon with no regeneration pink water treatment system. Operations at 50 to 60 percent of capacity probably are at best only marginally cost-effective. Operations below 50 percent of capacity incur significant cost penalties.

6.0 RECOMMENDATIONS

Based upon the assumptions, findings and conclusions presented in this study it is recommended that:

6.1 Forward this report to the Army representatives (see paragraph 1.1.4) who generated the basis for this study and solicit their comments on the findings and follow-up actions.

6.2 The U.S. Army identify for detailed cost analysis and study a specific (either existing or planned) carbon column pink water treatment plant to validate the actual costs associated with its operation and maintenance (Milan AAP is a suggested candidate plant).

6.3 The planning of new or modification of existing carbon treatment systems for pink waters include influent storage capacity equivalent to at least the design capacity of the plant.

6.4 When daily influent flow rates are less than the design capacity of the plant and storage capacity is available, the plant should be operated on an "intermittent" (as defined in this report) with part-time operators, rather than on a "daily" basis. This is especially significant if influent flows are less than 50% design capacity.

7.0 REFERENCES

1. Ciccone, V. J., et al., "A Present Value-Unit Cost Methodology for Evaluating Wastewater Reclamation and Direct Reuse," Water Resources Bulletin, Vol. 11, No. 1, 1975.

2. Morgan, J. M., Jr., Ciccone, V. J., and Martin, J. E., Economic Evaluation of Munitions Manufacturing Wastewater Treatment Alternatives Using a Present Value-Unit Cost Methodology, Prepared for U.S. Army Mobility Equipment and Development Command, Fort Belvoir, VA. Contract No. DAAK70-76-C-0052, Feb. 1980.

3. Ciccone, V. J., et al., Economic Evaluation of Munitions Manufacturing Pink Wastewater Treatment Alternatives Using a Present Value-Unit Cost Methodology, Prepared for U.S. Army Toxic and Hazardous Materials Agency and U.S. Army Mobility Equipment Research and Development Command, Fort Belvoir, VA. Contract No. DAAK70-80-C-0101, Feb. 1982.

4. V. J. Ciccone & Associates, Inc., Reconciliation of Present Value-Unit Costs for Munitions Manufacturing Pink Wastewater Treatment Alternatives. Report of Task I, prepared for U.S. Army Toxic and Hazardous Materials Agency and U.S. Army Mobility Equipment Research and Development Command, Fort Belvoir, VA. Contract No. DAAK70-82-M-0308, Jan. 1983.

DISTRIBUTION LIST

Addressee	Number of copies
Commander U.S. Army Toxic and Hazardous Materials Agency ATTN: DRXTH-TE-D DRXTH-ES	 3 2
Defense Technical Information Center Cameron Station Alexandria, Virginia 22314	3
Commander U.S. Army Material Development and Readiness Command ATTN: DRCIS-A 5001 Eisenhower Avenue Alexandria, Virginia 22333	 1
U.S. Army Armament Material Readiness Command ATTN: DRSAR-ISE DRSAR-IRI-E Rock Island, IL 61299	 1 1
Comander U.S. Army Armament Research and Development Command ATTN: DRDAR-LCM-SA Dover, NJ 07801	 1
Commander U.S. Army Munitions Production Base Modernization Agency ATTN: SARPM-PBM-EC Dover, NJ 07801	 1
Commander U.S. Army Mobility Equipment Research and Development Command ATTN: DRDME-GS Fort Belvoir, VA 22060	 1-2
Defense Logistics Studies Information Exchange U.S. Army Logistics Management Center Fort Lee, VA 23801	 2

FILME

3-8